although different from a theoretical view, obtained the same and the best result when compared with the TPS (96.2% of points passed the criteria as a mean value of all the fields and the median γ value was 0.559). The Mendez method obtained 84.9% and 0.747 respectively and the worst result was obtained with the ratio method as expected since this is not an enhanced dosimetry method (76.5% and 0.818). However when compared with the measurement the Mendez method (96.7% - 0.493) obtained better results than the Micke method (90.0% - 0.712). It must be pointed out that the implementation is based on these references but there are some differences, e.g., the function used by Mendez is not a polynomical function but a rational one. Mendez uses a genetic algorithm to obtain several fitting parameters and we employ another global optimization algorithm.

Conclusions: The Micke (& Mayer) and Mendez methods are suitable for this type of calibration. The Micke method is less complex than the Mendez method because the former does not need any optimization method nor image registration since its calibration is based only on 6 irradiated film fragments (a curve fitting is only needed). We think that the Mendez method is a very robust method and we have found very good results (with 2 mm - 1% a mean value of 100% was obtained and it has proved to be the best when compared with measurements) although the wedge calibration procedure is the critical point.

EP-1362

Influence of the phantom material on the absorbed-dose energy dependence of the EBT3 radiochromic film

M. Hermida-López[1], L. Lüdemann[2], A. Flühs[2], L. Brualla[3]
[1]*Hospital Universitario Vall d'Hebron, Physics Department, Barcelona, Spain*
[2]*Strahlenklinik Universitätsklinikum Essen, Medical Physics, Essen, Germany*
[3]*Strahlenklinik Universitätsklinikum Essen, NCTeam, Essen, Germany*

Purpose/Objective: Water is the reference medium for radiation therapy dosimetry. However, for film dosimetry it is more practical to use a solid phantom. As the composition of solid phantoms differs from that of water, the energy dependence of film exposed within solid phantoms may also differ. The energy dependence of a radiochromic film for a given beam quality Q (energy for monoenergetic beams) has two components: the intrinsic energy dependence and the absorbed-dose energy dependence f(Q), the latter of which can be calculated through a Monte Carlo simulation of radiation transport. We used Monte Carlo simulations to study the influence of the phantom material on the absorbed-dose energy dependence of the EBT3 radiochromic film (Ashland Specialty Ingredients, Wayne, NJ) for photon beams with energies between 3 keV and 18 MeV.

Materials and Methods: The simulations were carried out with the general-purpose Monte Carlo code PENELOPE 2011. The geometrical model consisted of a cylindrical phantom, with the film positioned at different depths depending on the initial photon energy. We simulated monoenergetic parallel photon beams and X-ray beams from a superficial therapy system. To validate our choice of simulation parameters, we also calculated f(Q) for older film models EBT and EBT2 comparing with published results. In addition to water, we calculated the absorbed-dose energy dependence of the EBT3 film for solid phantom materials commonly used for film dosimetry: RW1 and RW3 (PTW-Freiburg, Freiburg, Germany), Solid Water (Gammex-RMI, Madison, WI) and PMMA. Finally, by combining our calculated f(Q) with published overall energy response data we obtained the intrinsic energy dependence of the EBT3 film in water.

Results: Our calculated f(Q) for EBT and EBT2 films were statistically compatible with previously published data. Between 10 keV and 18 MeV, the variation found in f(Q) of the EBT3 film for water was within 2.3%, with a standard statistical uncertainty less than 1%. If we consider the quantity dose-to-water in the phantom, which is the common practice in radiation dosimetry, the maximum difference of energy dependence for the solid phantoms respect to water is about 6%, at an energy of 50 keV.

Conclusions: The EBT3 film shows a reasonably constant absorbed-dose energy dependence when irradiated in water. If we consider the dose-to-water in the phantom, the maximum difference of EBT3 film energy dependence with the solid phantoms studied respect to water is about 6% (at an energy of 50 keV). The reported overall energy dependence of the EBT3 film in water at energies below 100 keV is mainly due to the intrinsic energy dependence.

EP-1363

A database application to investigate the validity of the nanodosimetric approach

T. Schneider[1], M.U. Bug[1], H. Rabus[2]
[1]*Phys. Techn. Bundesanstalt (PTB), AG 6.63 Biological Effectiveness of Ionizing Radiation, Braunschweig, Germany*
[2]*Phys. Techn. Bundesanstalt (PTB), FB 6.6 Fundamentals of Dosimetry, Braunschweig, Germany*

Purpose/Objective: In radiotherapy with protons and heavier ions, the current concept of treatment prescription is based on the product of absorbed dose to water and a weighting factor, the relative biological effectiveness (RBE). This concept has its limitations in providing a generic method to quantify the biological outcome of a radiation treatment due to the different biological dose response of ion therapy compared to high-energy photon beams. A potential means for characterising radiation quality in a general way may be that of nanodosimetry. Nanodosimetry strives to link phenomenological dosimetric concepts, such as radiation quality and RBE, to measurable physical quantities related to the track structure of ionising radiation [1]. The track structure is characterised by the frequency distribution of the ionisation cluster size (ICS), which is the number of ionisations produced by a single particle within a specified volume. To investigate the range of validity for this approach, a database application has been developed which contains both experimental biological data for cell survival after ion radiation and calculated frequency distributions of ICS. The correlation between nanodosimetric quantities and cell survival data has been analysed by means of statistical tools.

Materials and Methods: A database-application was programmed utilising pandas [2], an open source library providing high-performance, easy-to-use data structures and data analysis tools for the Python programming language. As a starting point, biological data were assembled using the Particle Irradiation Data Ensemble (PIDE) [3], which is a collection of radiobiological data of more than 800 pairs of in-vitro cell survival experiments after photon or ion irradiation. For each radiation quality in the PIDE-Database, the corresponding ICS distributions (ICSD) were calculated with the PTB Track structure code (PTra) [4, 5] for specific nanodosimetric parameters, such as size, shape and material composition of the specified target volume (STV), as well as its distance and direction with respect to the particle beam.

Results: Nanodosimetric quantities were calculated from the aforementioned ICSDs (i.e. the mean ionisation cluster size M_1, or the cumulative probability distribution F_K of ICS, given the probability that an ICS of K or larger is produced in the target volume). The ascertained correlations to the biological data will be presented.

Conclusions: The database application is a useful resource for investigating the range of validity of the nanodosimetric approach.

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EP-1364

Proposal of thermal neutron detector stability for peripheral dose estimation in clinac at a novel neutron facility

J. Praena[1], L. Irazola[2], B. Fernández[1], J.A. Terón[3], R. Bedogni[4], M. Lorenzoli[5], A. Pola[5], B. Sánchez-Nieto[6], F. Sánchez-Doblado[2]

[1]*Centro Nacional de Aceleradores, CNA, Sevilla, Spain*

[2]*Universidad de Sevilla, Departamento de Fisiología Médica y Biofísica, Sevilla, Spain*

[3]*Hospital Universitario Virgen Macarena, Servicio de Radiofísica, Sevilla, Spain*

[4]*Laboratori Nazionali di Frascati, Istituto Nazionale di Fisica Nucleare, Frascati, Italy*

[5]*Politecnico di Milano, Dipartimento di Ingegneria Nucleare, Milano, Italy*

[6]*Pontificia Universidad Católica de Chile, Instituto de Física, Santiago, Chile*

Purpose/Objective: This work aims to design a stability verification system for thermal neutron detectors, based on the characterization and implementation of a fixed neutron fluence beam from a 3 MV tandem facility. The goal would be to minimize the noticed loss of sensitivity with accumulated dose in time and the constancy of the physical-chemical deposition of *TNRD* detector. This will guaranteed a correct behavior of these detectors for peripheral neutron dose estimation [1] in clinical environments when using photon beams over 8 MV.

Materials and Methods: Neutron beams can be obtained by means the ^{7}Li(p,n) and D(d,n) reactions, setup shown in Figure (a). *TNRD (Thermal Neutron Rate Detector)* [2], as most of the neutron detectors are mainly sensitive to the thermal component but photon presence can disturb the signal. Preliminary tests (detector-source distances and angles, plastic material thickness and photon rejection) were performed with epithermal neutron beam (0-100 keV neutron energy) following a quasi-Gaussian distribution by means of the ^{7}Li(p,n), with proton energy near-threshold, in order to have an appropriate neutron thermal fluence. With this information, several Monte Carlo simulations have been carried out to propose an optimal solution.

Results: As expected, tests showed that photon contribution increases when getting closer to the beam and thermal neutron signal increases when a thicker polyethylene block is used while decreases with distance. Thus a compromise between these aspects has to be found in order to ensure an acceptable noise-signal ratio. A solution based on the D(d,n) reaction at E_d=500 keV [3] was found with MCNPX simulations. Figure (b) shows the simulated normalized neutron flux integrated over the cell, with the dimensions of the *TNDR*. One million neutrons can be achieved with 1 hour irradiation using 500 nA deuterium current, polyethylene thickness of 2 cm, 2.1 cm distance between *TNDR* and neutron production target and the detector perpendicular to the beam.

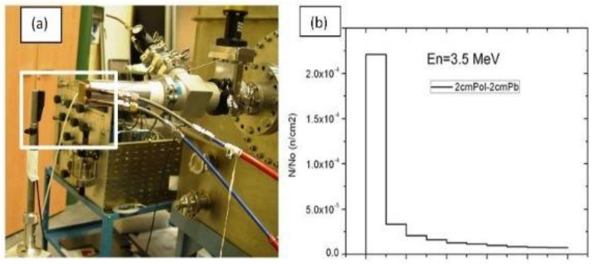

Figure. *(a) Neutron beam setup with TNRD detector located in front of the target. (b) Simulated neutron flux integrated over the TNDR normalized to the total number of neutrons generated in the simulation.*

Conclusions: Periodic measurements in a reference neutron facility should be considered to ensure thermal neutron detectors accuracy. The proposed setup added to the tandem facility, could be an adequate system to perform periodic stability measurements for this type of devices. The neutron spectra obtained from the D(d,n) reaction and polyethylene moderator may fulfill the requirements. Additional future measurements will be performed to verify the viability of the facility for neutron detectors stability verification and to study the possibility to establish as future calibration procedures.

Ref.

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Investigation of new phantom materials for QA in deep hyperthermia treatments

J. Hartmann[1], B. Frey[2], G. Futschik[3], C. Stumpf[4], C. Bert[1]

[1]*University Clinic Erlangen and Friedrich-Alexander-Universität Erlangen-Nürnberg, Radiation Oncology, Erlangen, Germany*

[2]*University Clinic Erlangen, Radiation Oncology, Erlangen, Germany*

[3]*Dr. Sennewald Medizintechnik GmbH, Munich, Germany*

[4]*Friedrich-Alexander-Universität Erlangen-Nürnberg, Institute of Microwaves and Photonics (LHFT), Erlangen, Germany*